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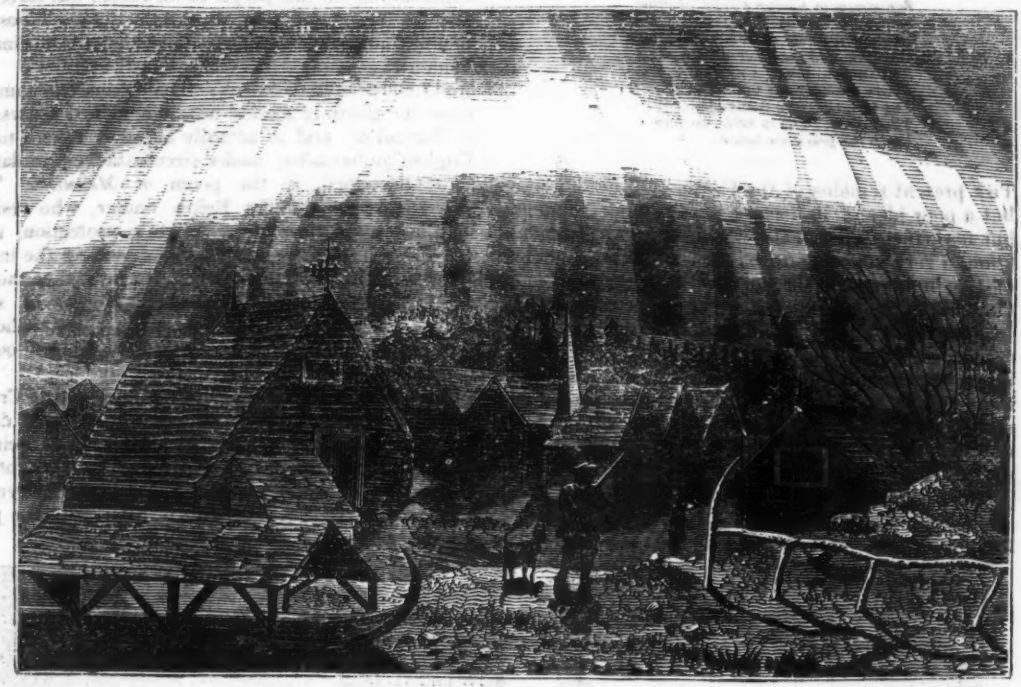
ON THE WEATHER. No. III.



AURORA BOREALIS. AS SEEN IN NORWAY.

THE RAINBOW

The Rainbow is the best known, and most beautiful of all meteors. It is observed when the spectator stands between a luminary, whether the sun or moon, but most commonly the former, and a mass of drops of water, whether in the form of cloud, spray, or rain. But the spectator must not be *in* the shower or vapour, he must be *between* the source of light and the water, or at least that portion of the mass of cloud in which he is immediately enveloped will not contribute to the formation of the bow.

Suppose a single ray coming from the sun to fall on a globe of water, if it pass through the centre of the sphere, the ray will not be *refracted* at all, and will only be partially *reflected* from the convex and concave surfaces, without undergoing any change or separation; but if the ray fall on the sphere in any other point, it will be more or less refracted on entering the water, according to the degree of obliquity with which it meets the surface of the sphere; the refracted ray will pass through the water, and will be *reflected* by the further concave surface from one or more points of it, according to the angles at which it falls on that surface. This reflected portion of the original ray will finally quit the sphere towards the quarter from which it originally proceeded, but not parallel to the original ray. A large portion of the ray will emerge from the sphere at each point of reflection, and be lost; and hence the intensity of the light that finally comes out, is much less than that of the original ray.

Now supposing the eye a fixed point, there must be an immense number of the infinitely numerous parallel rays coming from the sun, that will meet with drops of water constituting the cloud, spray, or rain, in that position, and at that angle, that will cause these rays, on their final emersion from the drops, to be reflected to the eye. But as each ray, according to its colour, has its particular angle of refraction, the white homogeneous solar rays will be separated in the drops of water into their component elementary rays, and each set of these will come to the eye at different angles, and produce an image of separate, parallel, or rather concentric, bands. We must now explain why these bands are circles; it is not because the earth is spherical, or the sun a globe, that a *bow* is formed; but simply because the drops of water are equal *spheres*, because the eye is a point, comparatively speaking, and because the rays are parallel, (or diverge from a point*); the bow, in short, is the result of the uniformity of the angle at which the same kind of ray is refracted and reflected in the same medium.

Those rays which, after refraction and reflection, ultimately reach the eye, form, in travelling from the luminary to the cloud, a series of concentric *cylinders*, having the line passing through the luminary and the eye for their common axis. The drops of water which reflect and refract the rays forming these cylinders, must form concentric circles. The rays, after their final emersion from these circles of drops, in their progress to the eye, form right *cones*, having a common axis and vertex, and it is these *cones of rays* that impress the mind with the idea of concentric coloured bands.

Since the drops of water are in continual motion, either falling to the earth as rain, or floating in air and driven by the slightest current, it might appear strange that the

* A rainbow may be made by rays from a luminous body at a finite distance from the spectator, such as a torch, &c.; in this case the rays proceed from a point.

rainbow should be steady and permanent, not having any tremulous or fluctuating motion. The reason is, that each drop in falling, as it were, through any one ray of light, causes this ray to undergo every modification of refraction that drop is capable of causing; and so infinitely rapid is the motion of light, that each of these modifications in succession arrives at the eye, and causes an impression on the retina as it is produced during the passage of the drop. But this impression on the mind continues sufficiently long after the drop has passed on, to allow another drop to come into precisely the same position with respect to the ray, and to undergo the same modifications; and as the various angles that the ray must form with its preceding position are immutable, they must be seen, *by a stationary eye*, in precisely the same direction

By attending to these principles, the reader will easily perceive why no two spectators can see the same bow; or more correctly speaking, receive the same reflected and refracted rays, and in the same direction; and also why the bow shifts its place, as either the spectator or the luminary moves. Since the centre of the circle, or arch, is in a line with the spectator's eye and the luminary, when the sun is at some height above the horizon, the rainbow will always be less than a semicircle, the earth intercepting that portion of the cylinders of rays, that would by their refraction complete the rest of the circle. When the sun is on the horizon, the bow will be a semicircle.

In general, only one coloured band or bow is distinctly seen, but in favourable circumstances, a second bow, concentric with the first, but fainter in its colours, may be discerned. This second bow is produced in precisely the same way as the first, only the cylinders of rays which originate it have undergone *two* reflections and refractions in the drops, in consequence of the obliquity of the angle at which they first meet the spherical surface, whereas the rays which originate the principal bow have only been *once* reflected within the drops. The original light being still further dispersed by the double reflection; the secondary bow is much fainter, and it will have the order of the prismatic colours composing it reversed,—that is, the red band will be innermost and the violet outermost, which is just the contrary to what takes place in the principal bow.

Lunar rainbows are very rarely *seen* from their faintness, and because few persons are abroad at night to notice them, but they might be witnessed whenever the same combination of causes occur. The moon must be at the full to produce light enough, the cloud very black, or fully charged with drops, to furnish a sufficient back-ground to the prismatic colours; even with these favourable conditions, coloured bows are hardly ever distinguished, the bow being usually only of a pale light of different shades.

If the mass of clouds or falling rain be unequal, the bow will be of different strength, and if the mass be interrupted so will be the bow. We often see only the lower part of the arch on one side, because the mass of cloud is not sufficiently extended to produce more. Instances have been known when several detached portions of a bow have been observed, produced by separate floating clouds.

Since the presence of globules of water in sufficient number, and a luminous body, are alone essential to the formation of an arch of coloured bands, or of the spectrum, this appearance may be witnessed on other occasions than in a cloud of rain, and reflection and refraction will sometimes produce singular anomalies in the phenomenon.

Besides the first and secondary bows, others, differently coloured, have been occasionally observed, and the space within the bow will sometimes appear lighter than the rest of the atmosphere. An inverted bow has been noticed on the grass when this has been copiously dewed; Captain Parry saw one, beautifully coloured, on a field of ice covered with snow; and a rainbow seen at sea is sometimes reflected on the ocean, and thus the circle completed*.

Colourless bows are produced in thin light mists; these are called *haze-bows*, and are not unfrequent in high northern latitudes and in mountainous countries. One remarkable appearance we may notice here, connected with the subject of fogs and mists. A person standing on a mountain-peak, and surrounded by a fog, will see his shadow cast on a mass of vapour opposite him, with a luminous glory surrounding that of his head; this is a rainbow produced under circumstances which allow of the whole circle being formed.

* See *Saturday Magazine*, Vol. VI., p. 245, for some beautiful verses on the Rainbow, by Thomas Campbell, in which this reflection is alluded to.

THE AURORA.

THE *Aurora Borealis*, or *Australis*, as it is termed, accordingly as it is seen in the northern or southern hemispheres, is a meteor that justly excites the greatest interest, both from its intrinsic singularity and beauty, and because it has hitherto defied all attempts to account *satisfactorily* for it. Aurora is mostly seen in these latitudes in Autumn, or during cold weather, and its frequency and brilliancy appear to augment, the higher the latitude.

Mr. Dalton describes the brilliant Aurora, which appeared on the 13th of October, 1792, in the following terms: "Attention was first excited by a remarkably red appearance of the clouds to the *south*, which afforded sufficient light to read by at eight o'clock in the evening, though there was no moon nor light in the north. From half-past nine to ten there was a large luminous horizontal arch to the southward, and several faint concentric arches northward. It was particularly noticed, that all the arches seemed exactly bisected by the magnetic meridian†. At half-past ten o'clock streamers appeared very low in the south-east, running to and fro from west to east; they increased in number, and began to approach the zenith apparently with an accelerated velocity, when, all of a sudden, the whole hemisphere was covered with them, and exhibited such an appearance as surpasses all description. The intensity of the light, the prodigious number and volatility of the beams, the grand intermixture of all the prismatic colours in their utmost splendour, variegating the glowing canopy with the most luxuriant and enchanting scenery, afforded an awful but, at the same time, the most pleasing and sublime spectacle in nature. Every one gazed with astonishment, but the uncommon grandeur of the scene lasted only about one minute; the variety of colours disappeared, the beams lost their lateral motion, and were converted into the flashing radiations. Altogether, this Aurora lasted for several hours; there were many meteors, or falling stars, seen at the same time, but they appeared to be below, and unconnected with the Aurora."

Captain Parry, in his account of the third voyage to discover the North-West Passage, during the years 1824-5, states that the Aurora was observed twice in October, five times in November, seven in December, fifteen in January, thirteen in February, and five times in March. "By far the greater part of these phenomena assumed one general character, and occupied nearly the same position. It usually consisted of an arch, sometimes tolerably continuous, but more frequently broken into detached irregular masses, or nebulæ, of light, extending from about West to South-East, (true,) which bearings correspond with N.E. by N. and W. by S. (magnetic). It sometimes, however, extended a few points beyond these bearings, but very rarely occupied any of the northern part of the heavens."

"On the whole, the arch seems to have been more frequently bisected by the plane of the magnetic than by that of the true meridian. The altitude of the upper margin of a permanent arch seldom exceeded ten or fifteen degrees, and from this coruscations were generally observed, shooting towards the zenith. In a few instances the arch itself passed as high as the zenith; and on a single occasion, the 28th of January, 1825, its direction was from true North to South. The lower edge of the arch was generally well defined and unbroken, and the sky beneath it appeared, by contrast, so exactly like a dark cloud, (to me often of a brownish colour,) that nothing at the time of viewing it could well convince one to the contrary, except the stars shining there with undiminished lustre.

"About midnight, on the 27th of January, this phenomenon broke out in a single compact mass of brilliant yellow light, situated about a S.E. bearing, and appearing only a short distance above the land. This mass of light, notwithstanding its general continuity, sometimes appeared to be evidently composed of numerous pencils of rays, compressed, as it were, laterally into one; its limits, both to the right and left, being well defined, and nearly vertical. The light, though very bright at all times, varied almost constantly in intensity, and this had the appearance (not an uncommon one in the Aurora,) of being produced by one volume of light overlaying another, just as we see the darkness and density of smoke increased by cloud rolling over cloud. While we were admiring the extreme beauty

† The meridian passing through the *magnetic* North and South as indicated by a needle at the place; *the true* meridian passes through the pole and zenith, and cuts the horizon in the true North and South points

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of this phenomenon from the observatory, we all simultaneously uttered an exclamation of surprise, at seeing a bright ray of the Aurora shoot suddenly downward from the general mass of light, *and between us and the land*, which was then distant only three thousand yards. Had I been the sole witness of this, I should have received with caution the evidence of my own senses, but the appearance conveying precisely the same idea to three individuals at once, I have no doubt the ray of light actually passed within that distance of us.

"It was always evident enough, that the most attenuated light of the Aurora sensibly dimmed the stars, like a thin veil drawn over them. We frequently listened for any sound proceeding from this phenomenon, but never heard any."

It appears that the duration of the Aurora is very variable; sometimes it forms and disappears in the course of a few minutes, at others it lasts during the whole of the night, and even for two or three days together. Muschenbroek observed one in 1734, which lasted ten successive days and nights.

The appearance of Aurora, in high northern latitudes especially, has been supposed to be accompanied by audible sounds, variously described by different narrators;—according to some it resembles the *rustling* of a silk flag, when waved to and fro in the air; by others it has been compared to a *crackling* sound; by others again to the *rushing* of wind, &c. The decided evidence of Captain Parry and of Mairan against the existence of any sound accompanying the appearance of Aurora, would seem to imply that this, like the other exaggerated statements of early writers, originated in the suggestions of imagination uncontrolled by the discipline of philosophy. Motion and sound are so commonly conjoined, that it requires some effort to prevent the appearance of the one from necessarily exciting, by association, the idea of the other; and when electricity was especially assigned as the cause of Aurora, the peculiar noise attending the transmission of the fluid through non-conducting substances, was, perhaps, presumed to be also an attendant of so remarkable a manifestation of it.

The first remarkable fact attending the appearance o Aurora which might seem to lead to some explanation of its cause, is the disturbance that it occasions in the magnetic *declination*, *dip*, and *intensity*, as indicated by the needle. And since these perturbations have been observed, when the Aurora which accompanied them was not visible above the horizon of the place, owing to its remoteness, it seems reasonable to suppose that there must be some connexion between this atmospheric and the unknown agency which produces electrical and magnetic phenomena. Nevertheless, the only plausible solution of the problem which has yet been given, does not appear more immediately connected with electric agency than every other chemical action. The hypothesis alluded to is, that Aurora is the light given out during the congelation of vapour or water suspended in the atmosphere; observation has shown that under certain circumstances light is given out during the solidification of water, as heat necessarily always is; and since crystallization is now known to be intimately connected with electric or galvanic agency, the action of Aurora on the needle is thus obscurely hinted at. But our readers must bear in mind that our knowledge of the facts themselves attending the appearances of Aurora, are far too vague and scanty to admit of any but the purest hypothetical reasoning on the subject, and that it is still involved in complete obscurity, which nothing but long-repeated and accurate observation can remove

It should seem, from a few observations recently made, that the appearance of an Aurora is a precursor of wind, wet, or cold, or of some marked change in the weather. The month of October this year, which was particularly wet and boisterous, produced several auroras, and one of remarkable brilliance. "The first aurora observed, occurred on September 30th. On the following day there was a decreasing barometric column, a strong south-west wind, and torrents of rain. On October 4th another aurora occurred, and on the next day a decreasing column, and a fal of rain amounting to nearly an inch and a half.

"An aurora on the 11th, in the evening, displayed, during four hours, luminous arches, and a vast field of light. Again, on the next day, there was a gradually decreasing column; rain; and then came on those south-west gales which were so severe and fatal on the coasts.

"The last observed aurora was visible on the 18th, and attracted universal notice in the metropolis, from the great extent of its deep-red colour*. Rain followed, but the barometric column, in this case, did not sink; on the contrary, it steadily rose, and its ascent exceeded the mean height.

"A comparatively dry period succeeded; the atmospheric pressure remained high until the 27th: it then fell with the north-westerly wind which preceded and brought in the late cold weather and deep snow."—*Magazine of Popular Science, and Journal of the Useful Arts*, vol. II., p. 404.

SHOOTING STARS AND METEORS.

EVERY one has occasionally observed on a clear fine night, in the latter part of the year especially, those bright transient meteors called *falling*, or *shooting stars*; there are, probably, several species of these, the differences between which are as little discriminated as their general origin is understood; properly, perhaps, only one or two of these species have any immediate connexion with the subject of these papers, and that but a slight one; nevertheless, we shall avail ourselves of this connexion, to give a brief sketch of our present state of knowledge on the subject, on account of the interest it just now excites in the scientific world. Since these meteors have been observed with some degree of accuracy, it has been found that, though formerly treated as unimportant, they are really deserving of attention; and that the usual superficial modes of accounting for them, by attributing their appearance to the casual inflammation of hydrogen gas, &c., are totally inadequate to explain the phenomena. Their parallax† proves that their situation, frequently, is much more distant than the sensible limits of our atmosphere. In observing what was the average direction of the motion of these meteors, it was indirectly ascertained that if they ignite in our atmosphere, they by no means originate there, but that they enter it from without. *This average direction of shooting stars appears to be directly contrary to that of the motion of the earth in its orbit*‡.

On the night of the 12th and 13th of November, 1833, shooting stars were observed in America in such numbers, and moving with such regularity of direction, as to present the phenomenon under a totally new point of view. The stars succeeded each other so rapidly that it was impossible to count them, and by moderate estimates they amounted to hundreds of thousands. An observer at Boston (U. S.) compared them, as regarded their number, to half that of the flakes in the air at one time, during an ordinary snow-storm; and when the phenomena had considerably diminished, he counted 650 in a quarter of an hour, although he confined his observations to a zone not comprising more than a tenth of the visible horizon.

Similar observations were made at different places along the eastern coast of America, from Mexico to Halifax, and the stars were seen moving in these numbers from nine in the evening till sunrise, and at some places till eight in the morning, by broad daylight. All these meteors proceeded from one part of the sky near γ Leonis.

The well-known American proneness to exaggeration, would, perhaps, have prevented these descriptions of so remarkable and novel a wonder from attracting much attention from scientific men in Europe, if other collateral testimony had not, in some measure, confirmed the circumstance of an unusually-numerous appearance of shooting stars at that season of the year. For instance, M. Humboldt observed in America, 1799, a similar *rain* of stars; and the Moravian missionaries in Greenland, and several persons in Germany, witnessed the same phenomenon at the same period, *which was on the night of the 11th and 12th of November*. And again on the night of the 12*th*

* "About 8 P.M., police, firemen, and boys, were running in all directions, expecting to find a fire in the next street, or at farthest, in the next street but one. The bustle and perplexity lasted about an hour."

† Parallax is the difference between the angles subtended by distant bodies when viewed from two different situations on the earth's surface. In walking along a road, trees in the neighbouring fields change their apparent angular distance, in consequence of our change of place; the difference in this angular distance is *terrestrial* parallax.

‡ Observations made at Breslau, Dresden, Leipsig, &c., by Professor Brandes and his pupils, showed that some shooting stars were five hundred English miles above the earth's surface, and that they moved with a velocity of thirty-six miles per second, a velocity nearly double that of the earth in its orbit round the sun. Admitting that half of this velocity was apparent only, resulting from the simultaneous motion of the earth, the remainder of eighteen miles indicates a greater velocity in these stars than that of all the superior planets.

and 13th of November, 1832, the appearance, on a smaller scale, was witnessed in Europe and Arabia.

M. Berard, commanding the brig *le Loiret*, while near Carthagena, off the coast of Spain, on *the 13th of November*, 1831, at four in the morning, witnessed a considerable number of shooting stars and luminous meteors of large dimensions, for more than three hours, during which time they must have appeared at the rate of two per minute. One of these meteors, which appeared near the zenith, left an enormous train from east to west, like a luminous band, as broad as the semidiameter of the moon, and showing prismatic colours; it remained visible for nearly six minutes.

On *the 13th of November*, 1835, a splendid meteor, larger in appearance than Jupiter, was observed at Lille; it left a train of sparks similar to those of a sky-rocket. And either this, or another, exploded and fell near Belley, in the *Departement de l'Ain*, where it set fire to some farm buildings.

The remarkable coincidence of dates, and the general uniformity of the direction of these meteors, as well as other circumstances regarding them, have led to the suspicion, that, besides the great planets composing our system, millions of small bodies are revolving round the sun, which only become visible to us when they penetrate our atmosphere, and are ignited in consequence; that these *asteroids* generally move in groups, but that there are isolated ones; and that the latter are the origin of the *aërolites*, or meteoric masses, that in all ages have, from time to time, fallen on our globe, while the general orbit of one of the groups is intersected by that of our earth about the 12th and 13th of November. But on this supposition it might be expected, that similar intersections with the orbits of other groups might happen at other periods of the year. Accordingly on the 20th or 24th of *April*, 1803, a *shower* of falling stars, moving in various directions, from one to three in the morning, was witnessed in Virginia and in Massachusetts; and Messier, on the 17th of June, 1777, about *noon*, saw a prodigious number of opaque spots pass across the sun's disk for about five minutes, which may have been a train of these asteroids passing in their orbit, and invisible to the earth except from their casual transit between us and the sun.

It is obvious that much relating to this subject must remain a matter of pure conjecture, or hypothesis, until repeated and accurate observations, for many years to come, furnish data for correct inductive reasoning. The attention of astronomers and meteorologists will, however, be now directed to the subject, and probably much curious information may come to light, that has been kept back from a belief in the unimportance of what have hitherto been considered solely as an *atmospheric* phenomena.

PROGNOSTICS OF THE WEATHER.

What is commonly called the power of *foretelling* the weather, is only the result of repeated observations on the comparative frequency with which certain *effects* accompany one another. If a certain final effect is most commonly found to be preceded by several separate, previous, and subordinate ones, the comparative certainty with which we may anticipate that final effect, depends on the number of the precursory ones that may be observed. We have repeatedly mentioned in the course of these papers, that we know but little of the proximate *causes* of atmospheric phenomena; and, whatever these causes may be, they act without our being able to recognize their existence at the time, except by means of some other subordinate or secondary effects wrought by them; and he will be best able to predict the final one, who has observed with the greatest attention, or in the greatest number of instances, these forerunners. It is obvious, that persons who pass much of their time in the open air, and whose pursuits and occupations are much influenced by states of the weather, are likely to observe with most attention all those minor effects we have alluded to; several of which would not attract that of one who for the most part was engaged in-doors.

Hence it is, that agriculturists, shepherds, gardeners, coachmen, but above all, fishermen and sailors, are so much more *weather-wise* than the mechanic or citizen; and from the constant necessity they are under of studying the minutest indications, or secondary effects, of meteorological changes, they arrive at the power of *foretelling* future changes, far exceeding the landsman's comprehension. If these persons could always explain clearly and simply the indications to which they trust, there is little doubt but that they would be found consistent with the soundest philosophy,—that is, they would be found to be the results of repeated and unbiassed observation: but a tincture of superstition, and the universal passion of wishing to excite surprise by the manifestation of superior *power*, whether mental or bodily, a passion most strong in proportion to the absence of general cultivation, induces this class of persons either to withhold their information, or deters them from telling candidly and simply what it is founded on. Nevertheless, we should not reject rashly those precepts which at first may *seem* trivial, or even absurd, merely because they come from a suspicious source; many *old-womens' prejudices*, as they were contemptuously designated by philosophers, in the plenitude of superficial knowledge, have been since proved to be founded on the more recondite properties of natural agents which had formerly escaped our observation. *Drawing out the fire* of a scald, or burn, by holding the injured part to the fire, was, in the medical school of *palliative* treatment, stigmatised as especially *anile* and dangerous; the *homœopathic* physician acknowledges the soundness of the principle, and the efficacy of its application. *That the sun does something more to put out the fire*, than merely by the liveliness of his beams with drawing our attention from the grate, is now proved by chemistry, as well as the experience of ages, to the discomfiture of those who used to laugh at the idea. With these and numerous other instances we could mention, before our minds, we may listen with scepticism, if we please, but not with ridicule or contempt, to the signs which the fisherman or sailor points out, as prognosticating conformable weather.

In the absence of that *tact*, that quick prescience of atmospheric changes, possessed by the class of persons we have above enumerated, and which can only be acquired by a similar course of discipline, the common observer *must* have a *barometer* to aid him in forming a guess, whether he should take an umbrella or a great coat out with him, or whether he had not better stay at home if he is not compelled to go abroad, or the reverse. Undoubtedly the best and most delicate mountain barometer ought to be preferred, but in default of the best, a good ordinary instrument will answer every purpose; we most strenuously, however, caution any one about to purchase a new one, to eschew that thing called a *wheel-barometer*, which, not to be utterly worthless, must be better made than we ever yet saw one made. A small column of mercury is acted on by every fluctuation in an elastic, gaseous medium; and can we suppose this delicate action can take place, if we load the mercury with the additional task of working a clumsy piece of mechanism, constantly getting deranged, and, when in its best trim, requiring a force of atmospheric pressure, perhaps, nearly equivalent to the tenth of an inch to overcome the inertia?

A thermometer is less absolutely necessary than the barometer, but the "curious in the weather" had better be provided with one, for reasons that he may glean from many parts of this paper; the thermometer should be hung out of doors in a northern aspect, protected from the sun, and as exposed to the free air as possible, but it should be sheltered from the direct influence of the sky above it*.

The observer should accurately know the aspect of his dwelling, and, indeed, should be able, at all times and places, to recognise the quarters of the compass, that he may observe the directions of the wind by means of smoke or the clouds, and he then need not care about having a vane in his garden, or even in his neighbourhood.

BAROMETRICAL INDICATIONS OF CHANGES IN THE WEATHER.

1. After a continuance of dry weather, if the barometer begin to *fall slowly* and *steadily*, rain will certainly ensue; but if the fine weather has been of long duration, the mercury may fall for two or three days before any *perceptible* change takes place, and the longer time elapses before the rain comes, the longer the wet weather is likely to last.

2. Conversely, if after a great deal of wet weather, with the barometer below its mean height, the mercury begins to *rise steadily* and *slowly*, fine weather will come, though two or three wet days may first elapse; and the fine weather will be the more permanent, in proportion to the

* See *Saturday Magazine*, Vol. IX., p. 86, note.

length of time that passes before the *perceptible* change takes place.

3. On either of the two foregoing suppositions, if the change immediately ensues on the motion of the mercury, the change will not be permanent,

4. The mercury will often rise or fall as has been just mentioned, for some time before the fair or wet weather which it prognosticates, begins; and it will then fall or rise during the continuance of this: that is, the mercury will often *appear* at variance with the existing state of the atmosphere. Under such circumstances, the principle before alluded to must be borne in mind; that the barometer only indicates the occurrence of some unknown change in the air, that *has* taken place, but the effect of which may, or may not, promptly follow its cause, owing to some modifying power that we know nothing of. Nevertheless, the instrument is a sure guide, when its fluctuations are not very rapid and very sudden, to those who choose to interpret it rationally and consistently. If the barometer rise slowly and steadily for two days together, or more, fine weather will come, though for those two days it may rain incessantly, and the reverse; but if the barometer rise for two days or more during rain, and then on the appearance of fine weather it begins to fall again, that fine weather will be very transient; and the same observation applies conversely to wet weather.

5. A *sudden* fall of the barometer in the Spring or Autumn, indicates *wind*; in the Summer, during very hot weather, a thunder-storm may be expected; in Winter, a sudden fall after frost of some continuance, indicates a change of wind, with a thaw and rain. But in a continued frost, a *rise* of the mercury indicates approaching snow.

6. When a violent gale has followed a sudden fall of the mercury, this frequently, and indeed, most commonly, begins to rise again very rapidly, especially about the seasons of the equinoxes; in this case the gale will not last long, but the ascent of the mercury is not to be taken as indicative of fine weather; on the contrary, a great deal of rain may ensue, and the barometer will quickly begin to sink again.

7. No *rapid* fluctuations of the barometer are to be interpreted as indicating either dry or wet weather of any continuance, it is only the *slow*, *steady*, and continued rise or fall that is to be attended to in this respect.

8. A rise of mercury late in the Autumn, after a long continuance of wet and windy weather, generally indicates a change of wind to the northern quarters, and the approach of frost.

ON INDICATIONS FURNISHED BY CLOUDS, &c.

THE present state of the sky and air, as regards its dryness or moisture, indicated by the kind and quantity of clouds, mists, dews, &c., must, of course, be taken into account when we wish to draw any conclusions as to immediate changes in the weather. Our information on this subject is hardly less vague than on others connected with that of meteorology generally; the following are the principal conclusions at which accurate observers have arrived, but they are liable to too many exceptions and modifications to be taken as any thing more than general guides.

1. If the sky be assumed as perfectly clear, after a continuance of dry weather, light streaks of *cirrus* appearing in it are the first indications of approaching change. These cirri increase by the lateral addition of others; they descend to a lower region, and become successively *cirro-stratus* and *cumulus*, till that modification takes place which converts them into *nimbi*, and rain commences.

2. Cirrus in the sky generally results from a change of wind in those upper regions, and the direction of the filaments, of course, indicate that of the new current; therefore, if the cirri are directed from the southern or western quarters, after the wind has been in the others, the rain may be more certainly anticipated, and the barometer will be found to be falling.

3. It is the prevalence of *cirro-stratus* towards the horizon, that causes the sun to appear as if setting in a fog, with that streaky effect which has always been thought to indicate rain before the morning; and the red and crimson streaks produced in sharper, well-defined lines of colour in the mass of such clouds at sunset, are considered indicative of wind and rain, or of stormy weather.

4. In hot summer weather, the sky during the finest days is often loaded with masses of *cumulus*, of clear, sharp, rounded outline, and brilliantly edged with light; with such a sky no immediate change need be apprehended; and towards evening these clouds disperse, breaking up into that intermediate modification called *cirro-cumulus*, the smaller detached masses of which are edged with the crimson and purple tints which, in all times, have been hailed as ominous of continued fine weather, and have given rise to the well-known doggrel,—

> An evening red and morning gray,
> Will set the traveller on his way;
> But an evening gray and a morning red,
> Will pour down rain on a traveller's head.

5. If, after such a sky as we have just described, the cumuli towards evening, instead of dispersing, congregate towards the horizon, and rise upwards with sharp outlines, and an unusual stillness and closeness is felt in the air, it is a sure sign of an approaching thunder-storm, and this sign will be corroborated by the barometer and electrometer.

6. In addition to the gray evening, a greenish tinge in the sky, towards the horizon, is usually a precursor of wet, and, like the distinctness with which distant objects can be seen, arises from the modification in the clearness and refractive powers of the air, occasioned by an excess of moisture.

7. But, whatever may be their form or character, an increase of the clouds, particularly towards evening, may be generally taken as indicating approaching rain, because accumulated moisture in the air must eventually return to the earth as rain.

8. The dappled, or mottled sky, produced by the prevalence of *cirro-cumulus*, when the small masses of cloud nearly melt into one another, is at all seasons and times of the day a sign of fine weather; but in the morning, *after* the sun has risen, may be safely relied on as such; it is this sky at that time of the day which is *gray* in colour. If the observer see such a sky, and observe the smoke to rise from the chimney straight upwards, and to a considerable height, he need hardly consult his barometer for a confirmation of such satisfactory prognostics.

9. Whenever *cirro-stratus* prevails, it forebodes rain, snow, or hail, according to the season; and especially when towards evening an extensive even sheet of this cloud is spread over the greater part of the sky, a fall of steady rain is usually the consequence.

10. At all seasons *cirro-cumulus* is seen in the intervals between showers; its prevalence is a tolerably constant precursor of increasing temperature; it is a modification of this cloud which presents itself before thunder-storms, with sharp, rounded outlines, its surface broken into smaller cumuli, and often of a lurid colour.

11. In wet weather, when the air is damp, cirri which appear in the intervals of rain are undefined in outline; and whenever this cloud loses its distinct, filamentous character, and becomes feathery and soft, wet may be expected.

12. Halos round the moon are considered a tolerably certain sign of rain, even when there is no apparent cloud intervening to form them.

INDICATIONS OF THE CHANGE OF WEATHER FURNISHED BY ANIMALS, &c.

THE peculiar feelings of uneasiness experienced by invalids, and indeed by many persons in perfect health, during certain states of the atmosphere, may fairly lead us to suppose, that animals must be also influenced in a similar manner; and the regularity with which the functions fulfil their purpose, being in this case uncontrolled by intellectual agency, animals manifest the results of any variation in that regularity, by a corresponding deviation from their usual habits. Now, though we know nothing of the connexion between atmospheric changes and their effects on organized bodies, we may safely and wisely trust to such deviations from the regular habits of animals, as indicating such a cause, and as well deserving of attention, provided we do not suffer our judgment to be biassed by any irrelevant associations of any kind. The following few observations on the influence of changes in the weather on man and certain animals have been made at all ages, and, therefore, may be safely taken as generally correct, and as illustrating this subject.

An unusual bustle is observed among ants, bees, and wasps at their nests; spiders come out of their recesses, and are seen crawling about at night; flies of all kinds are more active, and sting or bite, before rain. When gnats fly in compact bodies in the beams of the setting sun, it indicates *fine* weather; but if they retire under the shade of

trees at evening, rain may be expected. Snails and slugs appear in greater numbers during damp weather, and, therefore, before as well as after rain; and frogs are more lively and clamorous in the ponds and marshes at the same times.

The habits of insectivorous birds and beasts will be modified by changes in the weather, according as those changes influence the insects which are their prey; thus swallows fly low before rain, because the insects which they chase and capture on the wing, approach nearer the earth at that time. For a similar reason, bats being observed to flit long and late in the twilight, is considered a sign of a fair day on the morrow, and they do so because in calm and settled weather gnats, dorbeetles, and other insects, remain long on the wing in the evening. On the contrary, bats retiring early to their haunts, shows that their food is not to be met with, on account of approaching wet; and since this privation excites painful feelings in the quadruped, the cries of the bats, under these circumstances, have, probably, been regarded as a just prognostic of rain.

It has been observed that fish are eager in biting at flies at the surface of the water, and are more active before rain, for a similar reason.

Rooks return to their nests sooner than usual, when the grubs in the corn-fields bury themselves deeper in the earth against a change: but why those birds' circling in the air and descending to the earth successively in flocks is considered as ominous of wet we know not, nor do we profess to vouch for the fact.

But, besides being influenced by the abundance or scarcity of their food, modifications in the state of the air act on the lower animals, and induce them to utter cries or express their pleasure or pain in an unwonted manner. Asses are observed to bray more and to be more iritable before wet.

The uneasiness of pigs before a storm has been a theme of amusement in rural life, quite long enough to attest the truth of the observation; and sailors expect one when porpoises and dolphins gambol at the surface of the sea.

Peacocks and guinea-fowls, and many other birds, are particularly clamorous before rain, and the domestic cock manifests uneasiness by frequent crowing.

Cattle leave off feeding, and chase one another in their pastures at such times.

The vegetable kingdom furnishes abundant information on hygrometrical changes in the atmosphere, though but few facts are recorded, or observations on the subject made. The closing of the flowers of the *Anagallis arvensis* on dull days, has conferred on it the name of the *Poor Man's Weather-glass;* and many other plants merit the same title, as the *Calendula arvensis, Tragopogon*, &c. &c. But these effects are, in this case also, due to several causes, acting simultaneously; and since, from our limited knowledge, we cannot separate these causes so as to attribute the result to the more influential one, the information derived from plants, like that from animals, must always be uncertain, and comparatively useless, though interesting, and well deserving of attention.

The following verses embody most of the popular precepts on the subject, and are therefore curious. We have appended a note or two to those passages which require elucidation.

The hollow winds begin to blow,
The clouds look black, the glass* is low,
The soot falls down, the spaniels sleep,
And spiders from their cobwebs peep:
Last night the sun went pale to bed;
The moon in halos hid her head;
The boding shepherd heaves a sigh,
For see, a rainbow spans the sky!
The walls are damp, the ditches smell,
Closed is the light red pimpernel.
Hark! how the chairs and tables crack!
Old Betty's joints are on the rack;
Her corns with shooting pains torment her,
And to her bed untimely send her.
Loud quack the ducks, the sea fowls cry,
The distant hills are looking nigh†.
How restless are the snorting swine!
The busy flies disturb the kine.
Low o'er the grass the swallow wings,
The cricket too, how sharp he sings!
Puss on the hearth, with velvet paws,
Sits wiping o'er her whiskered jaws.
The smoke from chimneys right ascends,
Then spreading back to earth it bends.
The wind unsteady veers around,
Or settling in the south is found.
Through the clear stream the fishes rise
And nimbly catch the cautious flies.
The glow-worms, numerous, clear, and bright,
Illumed the dewy hill last night.
At dusk the squalid toad was seen,
Like quadruped, stalk o'er the green.
The whirling wind the dust obeys‡,
And in the rapid eddy plays.
The frog has changed his yellow vest,
And in a russet coat is dressed.
The sky is green, the air is still,
The mellow blackbird's voice is shrill.
The dog, so altered in his taste,
Quits mutton-bones on grass to feast.
Behold the rooks, how odd their flight!
They imitate the gliding kite,
And seem precipitate to fall,
As if they felt the piercing ball.
The tender colts on back do lie,
Nor heed the traveller passing by:
In fiery red the sun did rise,
Then wades through clouds to mount the skies.
'Twill surely rain, we see't with sorrow:
No working in the fields to-morrow.—DARWIN.

* The *glass* is an exceedingly illiterate, because vague and incorrect, appellation for the barometer

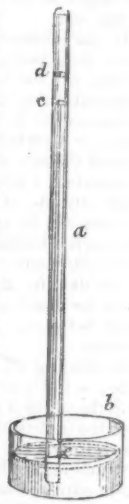
† An effect of the clearness of the air resulting from excess of moisture.

‡ An electrical phenomenon which was alluded to in our preceding numbers.

Dean Swift's well-known verses on a city shower also contain allusions to many of the same prognostics.

ON METEOROLOGICAL INSTRUMENTS.

OUR future progress in knowledge of the science of meteorology entirely depends on the multiplication of *accurate observations faithfully recorded*, and every contribution to the stock will be acceptable, provided these two indispensable conditions are fulfilled. Since it is in the power of many persons who have leisure, to make a series of meteorological observations, we think we cannot close these papers better than by giving a few precepts on the nature of the instruments necessary, and the mode of using them efficiently.



The BAROMETER has been generally explained in our fifth volume, p. 11, and most of our readers are familiar with the ordinary form of the instrument and with the mode of *reading* off its indications on a graduated scale; nevertheless, we will here again describe the principle of its *construction*, for the purpose of explaining the corrections that are required to be made before the true relative weight of the atmosphere can be ascertained by means of it. Let a glass tube *a*, closed at one end, and upwards of thirty-nine inches long, filled with pure mercury, be inverted in a *true cylindrical vessel, b*, containing a quantity of the same metal: the mercury subsides in the tube till the weight of the quantity above the surface of that in *b* balances a column of the atmosphere of equal diameter, a perfect vacuum being left in the upper part of the tube. Suppose the mercury stood in the tube at *c*, the instrument being at the level of the sea, and the thermometer at 32°. Then a graduated scale being made on the tube, the zero of which was at the level of the mercury in the cylinder, the height *e c* in inches, as indicated by the scale, would be that of a column of mercury which equalled in weight a column of the atmosphere; and when the weight of the latter varies, the mercury would rise or fall in the tube accordingly. If such a change in the air took place as raised the mercury to *d*, it is clear that the additional quantity requisite to fill the space *c d* must be abstracted from the vessel, and the level, therefore, of the mercury contained in it must *fall* to the dotted line, or below the zero of the scale, which would hence no longer indicate the true length of the column in the tube above the level in the vessel, as it ought to do. A fall of the mercury in the tube resulting from atmospheric causes, would *raise* the level in the vessel, and produce an analogous error in the scale the other way; the indicated height being *greater* than the true in this latter case, as it was *less* than the true height on the former supposition.

If the barometer could be left in the simple form we have described it, the correction for the scale might be made by changing the level of the mercury in the vessel, till it stood at zero of the scale at the time of observation, either by

inserting anything further into the mercury to raise it, if it were too low, or by withdrawing the same body out of it to allow the mercury to fall in the vessel if it were too high. A simple screw through the bottom of the cistern would perfectly answer this purpose. But as the vessel must be protected from the air, to preserve the mercury pure, the zero of the scale and the level of the mercury in the cistern could not be seen and compared; nor would this be absolutely necessary, in order to make the adjustment; for if the tube and the cistern were perfectly cylindrical, then equal distances on the former would correspond with equal elevations and depressions of the level of the mercury in the latter, the proportion between the variations in each being ascertained, which is easily done, since it is exactly inversely that of the diameters of the two, then for every quantity of elevation or depression, below that degree on the scale at which the quantity of mercury in the tube, admits of that in the cistern standing at zero, a quantity easily calculated may be deducted or added to the indicated height, to obtain the true one.

The total *volume* of mercury in the cistern and tube varies with every change of temperature; thus supposing the weight of the atmosphere, or its pressure, to be the same, the mercury in the tube would stand higher when the thermometer was at 70° than when it was at 32°; a correction, therefore, for temperature is necessary to reduce the apparent height, as observed, to what it would be if the observation had been made when the thermometer stood at 32°. This correction is not so simple as the last, but formulæ for it are investigated, and are to be met with in all works on the subject. The last correction which the barometer requires is that to reduce the observations to the level of the sea at the place, for the instrument can rarely be at that exact level, and any elevation above it depresses the height at which the mercury would stand if at the surface of the sea.

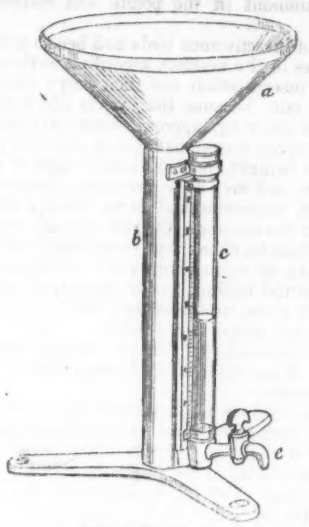
If the observer be unwilling or incapable of making these reductions, and have not a perfect instrument, his journal will not be the less valuable, provided he record the temperature at the time of each observation, indicated by a thermometer in contact with the barometer, provided he know, or ascertain, the height of the instrument above the level of the sea, and provided he has verified his instrument to ascertain whether the divided scale is correct at some fixed altitude of the mercury; for, in this case, the corrections can be applied by other, more competent, persons. But such a journal is valueless, if the observations be not *carefully* made and *faithfully* recorded at the same hours of the day, for at least a twelvemonth together. The best hours for observation are noon, midnight, and every three hours between, or at as many of these intervals as may be possible.

In reading off the height of the barometer, the moveable index is to be moved so that the upper edge may be level with the highest part of the convex summit of the mercury*, then the inches, tenths, and hundredths, may be read off from the vernier; the index should then be moved a little, the instrument slightly tapped with the hand, and the index again adjusted and read off; it is this second reading which must be registered, but the difference between it and the former will show whether the mercury is rising or falling, though to the practised eye the degree of convexity of its summit will afford this information at once.

We have nothing to remark here on the thermometer, except that the oftener the temperature is noted down the better, but it should be done always at the same hours each day whenever it may be done. This instrument must of course be out of doors, and should, if possible, be as far from any house or wall as convenient; the northern side of a wooden fence is the best situation, and the instrument should be at least five or six feet from the ground, but a careful observer should have two in different situations.

The Rain-Gauge.—The annexed figure represents a recently improved form of this instrument†, far preferable, from its simplicity, to the so-called self-registering gauge, which is obnoxious to the same reproach as the wheel-barometer, and equally liable to derangement.

A copper funnel, *a*, terminating in a small aperture, about a quarter of an inch in diameter, is fixed at the top of a cylindrical tube, *b*; this tube communicates at the lower end with one of glass, *c*, attached to *b*, and carrying a graduated box-wood scale. It is obvious that water will



THE RAIN GUAGE.

stand at the same height in the two tubes, and the relative quantity may be measured by the scale. A certain quantity of water is poured into the funnel, so that its surface may stand a little above the metal socket and be visible; this level is the zero of the scale. The diameter of the rim of the funnel being known, the quantity of water which would cover the surface of that rim, to an inch in depth, is calculated or measured; this quantity being poured into the tube, the height to which the water rises in the glass tube furnishes the division on the scale corresponding to an inch depth of rain‡; equal quantities would, of course, raise the water in the tube equally, or the divisions will be equal, and from the small diameter of the tube, compared to that of the rim of the funnel, an inch in depth on the surface of the latter will produce a rise of several inches in the tubes; this allows of small quantities of rain producing a very apparent rise in the tube, which can be measured by the subdivisions of this magnified scale.

If the scale be graduated by this mode of proceeding, it is obvious that the size and form of the funnel is unimportant, as the object is only to measure proportionate depth, not actual quantity. The instrument is mounted on a tripod, and should be screwed down to a board, to stand on the ground, to obviate its being overturned by the wind; the rim of the funnel should be horizontal. The reason for the small orifice of the funnel is to prevent rapid evaporation, which would prevent the true depth of rain from being ascertained; but since there will be some evaporation, notwithstanding every precaution, the gauge should be examined as soon after the rain has fallen as possible. When the instrument is set, the water must be drawn off by the tap, *e*, and a fresh quantity poured in, so that it may stand accurately at zero.

The Hygrometer is intended to measure the relative quantity of moisture in the air at different times. Some animal and vegetable hairs, or fibres, are acted on by wet, lengthening and shortening alternately, according to the dampness or dryness of the atmosphere; to render these changes perceptible, one end of the hair, or fibre, is fixed, the other is wound round a cylinder, carrying on its axis an index to move round a graduated dial plate; the minute contraction of the substance turns the cylinder, and consequently the hand moves a very perceptible quantity on the dial; on the contrary, when the fibre elongates, a spring, or a counterpoise, draws the cylinder back again in the contrary direction, as far as the expanded fibre will allow of its moving. This is the general principle on which Saussure's, Deluc's, and other ordinary hygrometers are constructed; but the substance employed loses its efficacy by long-repeated atmospheric action, and is never capable of affording either definite or accurate indications; these hygrometers are accordingly supplanted by a beautiful

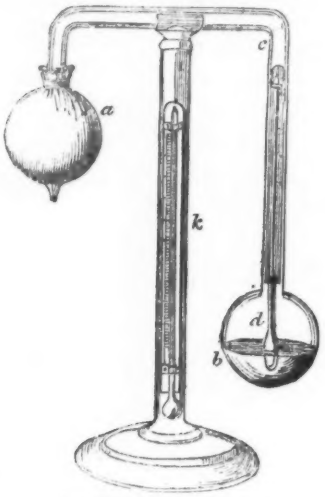
* The mercury is always *convex*, even when it is falling, though much less so in this case than when it is rising; it is absurdly stated in some works, that, when the barometer is falling, the mercury is concave at its top; this is an error.

† Made by Mr. Simms, of the firm of Troughton and Simms, of Fleet-street.

‡ See *Saturday Magazine*, Vol. IX., p. 170.

instrument, contrived by Mr. Daniell, which we shall briefly describe.

a and *b* are two glass bulbs at the extremity of a tube, bent into the form, and mounted on a stand, shown in the figure. The ball *b*, is filled two-thirds full of ether, which is made to boil in the bulb over a spirit-lamp; the vapour



THE HYGROMETER

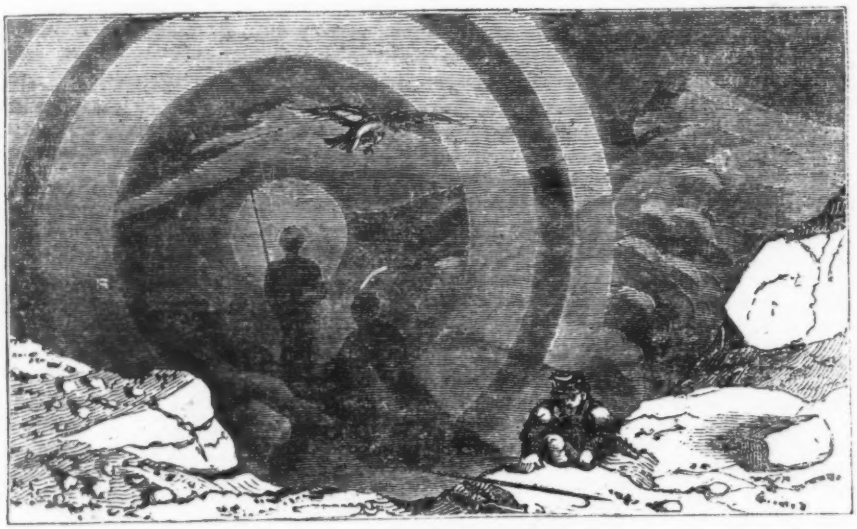
fills the whole space, and expels the air through the minute opening at the bottom of the ball *a*; this aperture is quickly closed up, hermetically*, while the ether is in this state. When the ethereal vapour on cooling condenses again into the bulb *b*, the rest of the interior of the glass is a vacuum, or only contains the vapour of the ether. A small thermometer is previously enclosed in the arm *c*, the lengthened bulb of which thermometer partly dips into the liquid ether; another thermometer, *k*, is attached to the stand, and the bulb *a* is covered over with a piece of muslin.

By holding the bulb *b*, the warmth of the hand will soon make the enclosed other boil, and convert some of it into vapour, which will fill the other bulb, *a*. The instrument is then to be placed out of doors, and the eye of the observer must be brought to the level of the ether in *b*, while a few drops of ether are to be dropped slowly from a phial on the muslin-covered ball. The evaporation which immediately takes place on the ball *a*, produces a rapid condensation of the vapour within. The artificial cold thus produced causes the aqueous vapour in the atmosphere to be condensed on the bulb *b*: its first appearance as a light cloudy ring at the level of the surface of the ether is to be carefully noticed, and the degree indicated by the enclosed thermometer, *d*, instantly marked down: this point, at which the vapour held in the air at any time is condensed, is called the *dew-point*, and affords a relative measure of the degree of moisture contained in the air at the time. The more nearly saturated the air is with moisture, the less will be the diminution of temperature requisite to reconvert the vapour into water; consequently, the higher the dew-point, the greater the moisture of the air. The thermometer attached to the stand shows the temperature of the air at the time of observation. If the enclosed one has only fallen a few degrees below the external thermometer, there must be a considerable degree of moisture in the air, which will probably be soon deposited in the form of rain. Hence the instrument in careful hands fulfils the purpose of a barometer, *as far as this latter is capable of predicting the approach of rain*; with the advantage that the fluctuations of the *dew-point*, as indicated by the Hygrometer, immediately result from the changes of state in the air which it is our object to ascertain; while the connexion between the fluctuations in the mercurial column and the state of the air on this respect, are but obscurely known to us; and our confidence in the barometer is founded only on long-continued observation of the existence of such a connexion, though we cannot explain it†.

The other meteorological instruments which are occasionally employed are the *Electroscope*, or *Electrometer*, to indicate the relative electrical state of the air, and the *Photometer*, to ascertain the relative quantity of solar light in different states of the air. But neither of these instruments being properly connected with the purpose of these papers, and neither being accurately appreciable in their indications, we shall not make any further allusion to them.

* A vessel is said to be hermetically sealed when it is perfectly air-tight; glass is impervious to any vapour or gas with which we are acquainted; when, therefore, a glass tube, such as that of a thermometer or of the instrument in question, is closed by melting one end and pressing it together while soft, the tube for ever after remains air-tight, and its contents unchanged.

† Great care must be taken in using the Hygrometer, that it be not breathed on, or unnecessarily approached by the body, as otherwise the warmth will affect the result. The same care, only to a greater degree, is necessary, and for the same reason, as is used in consulting a simple thermometer.



FOG-BOW, AS SEEN AMONG MOUNTAIN PEAKS.

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